AD-A134 602 CREEP AND SLIDING IN CLAY SLOPES: MUTUAL EFFECTS OF INTERLAYER SWELLING AND ICE JACKING(U) INNSBRUCK UNIV (AUSTRIA) K A CZURDA 24 APR 83 DAJA45-83-C-0010 1/1

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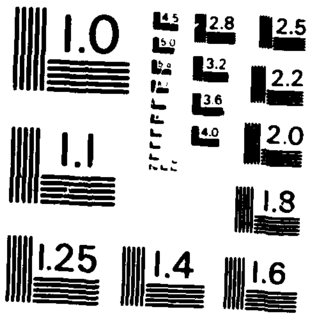
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Research Project: CREEP AND SLIDIDNG IN CLAY SLOPES: MUTUAL EFFECTS OF INTERLAYER SWELLING AND ICE JACKING

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Contractor: UNIVERSITY OF INNSBRUCK

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2nd Interim Report

Report Period: JAN. 24TH, 1983 - APRIL 24TH, 1983

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Innsbruck, 1983-04-27

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Summary: <u>Results up to Now</u>

The first short interim report was dedicated to the identification of the material we are dealing with and the geological setting within the Austrian Molasse formation. The material identification up to now comprises laboratory data concerning petrographical and physical properties. The miocene clay under investigation shows specific properties: montmorillonite content up to 32%, other clay minerals up to 55%, low quartz, calcite and feldspar constituents. Therefore a swelling clay with low diagenetic lithification (matrix forming) effects. Therefore, the clay shows high plasticity (i_p = 35%), determined not only by the high swelling clay content but also [illegible] the grain size distribution: 40 - 60% $<$0,002 mm, 40 - 60% 0,002 - 0,063 mm, 0 - 10% $>$0,063 mm.

The recent research period should give detailled bulk chemical-, interlayer cation- and cation exchange data: the bulk chemistry of three representative samples was analyzed by microprobe (Tab. 1) and the main exchangeable interlayer cations: Na^+, K^+, Ca^{++} and Mg^{++} were determined quantitatively (Tab. 2). The CEC depends mainly on the montmorillonite content and shows values up to 86 meq/100g, which indicates high montmorillonite clays. First freezing tests have been performed within a freezer. After freezing, three typical zones within the samples can be observed: a frozen top layer, dried up and microfabrically changed. A middle frozen part with ice lenses and therefore up to tripled water contents and a lower layer, unfrozen and almost unchanged in water content.

1. Bulk Chemistry and Interlayer Cations

The bulk chemistry and kind of absorbed interlayer cations has been determined for several clay samples (Tab. 1 and 2). The exchangeable cations have been treated with NH_4 CNS-solution thus sorbing these molecules, and replacing the original cations which are now concentrated in the supernatant solution. The final CEC-determination was determined by resaturation of the clay with Na Cl, the cations measured by an atomic absorption spectrometer (AAS). As Ca^{++} is the principal extracted interlayer cation, it is supposed that the chemistry of our montmorillonite is that of a Ca-montmorillonite, what could also be deduced from the bulk chemical analysis. Nevertheless some leaching out of the materials carbonate content may free and readsorbe Ca-ions.

Further investigations shall try to separate this montmorillonite from the other clay minerals, so that a more adequate analysis of its chemistry and of its cation exchange behaviour may be realized. This will be very important for the following freezing tests with different saline solutions.

2. Freezing Behaviour

For gaining first data on the freezing behaviour of the investigating montmorillonitic clay, a cold box was constructed (Fig.1).

A refrigerator, divided by an insulation plate in two compartments, should simulate natural freezing conditions. In the upper part, the cold compartment, the temperature could be varied between -6°C and -12°C. In the lower part, the warm compartment, the temperature changed between +10°C and +12°C.

An orientated taken clay sample from the freshwater clay at the test site was used for the experiment. Free movement of the sample during freezing was made pos_ible by setting the sample into a greased plastic tube. Water could be absorbed through a porous stone (Water absorption has only been measured during

the last two tests). The heave amount is registrated by a dial gauge, which is mounted on top of the sample. A thermo couple probe is introduced about half a cm into the clay to measure the temperature of the specimen next to the surface. (Fig. 1).

Up to now four freezing tests have been performed. The time of freezing ranges between 9 and 25 days for one test, i.e. as long as swelling could be observed. For the first two tests we took a prismatic sample (surface: 7,8 x 6,2 cm, height : 7,5 cm), for the last two tests we chose a cylindric sample (diameter: 8,1 cm, height : 7,5 resp. 8 cm).

At the end of freezing, the sample had the following configuration. The frost penetration depth lies approximately in the middle of the specimen. (Only at the fourth test the frost front is situated higher). The frozen part of the sample may be divided in a surface layer without ice lenses (1 to 4 cm thick), and a layer with one or more ice lenses (2 to 5 cm thick). In the first two tests the surface layer had mainly dried up (only 7 to 16% water), so that we chose the height of the plastic sample tube for the following tests several cm heigher than the height of the sample. The water content of the frozen layer between surface layer and frost front had doubled to tripled (80 to 130% water). The lower unfrozen part of the sample showed almost the initial water content (30 to 40%). Volume increase appears already a few hours after freezing starts, and generally stops after a week. The heave amount lies between 6 and 20 mm, except for the first test. Here we had a swelling of approx. 5 cm, that can surely be referred to lateral freezing when the sample was expanding out of the tube. The heave rate corresponds to nearly 10 to 25% in most cases of the sample's height. In most cases, the water absorption (15 resp. 41 ml) goes linear with the amount of heave (fig. 2 and 3).

A new freezing apparatus, where several samples can be installed at the same time, is under construction.

As a first step into the field investigation, soil thermometers are situated at the test site at Remigen.

3. Statement of Research Plans for the Coming Research Period

The clay identifications are not completed yet: especially the high CaO content of some samples, parallel with high heat losses and high CEC has to be checked and determined for some more samples. Further investigations have to concentrate on the type of montmorillonite and the CEC. Of course extensive freezing and swelling tests in the laboratory have to show parameters of this behaviour.

In the field the very difficult and tricky pore water pressure measurements will start with groundwater and penetration tests. The crucial question if water will be sucked from the ground water table up to the freezing front depends strongly on the depths of the ground water table and the penetration depth of the freezing front.

Chemical composition (%)	RE 9	RE 11/2	RE 12
SiO_2	61,26	45,97	61,07
TiO_2	0,75	0,71	0,61
Al_2O_3	17,20	19,43	18,17
Fe_2O_3 } FeO	6,05	6,43	6,20
MnO	0,12	0,28	0,10
MgO	1,80	0,84	1,63
CaO	2,76	9,62	1,63
Na_2O	0,29	0,30	0,34
K_2O	2,88	3,37	3,59
P_2O_5	0,09	0,19	0,08
Heat loss	6,81	12,86	6,59
total	100.01	100.--	100.01

Tab. 1: Chemical analyses of clay samples from test sites Remigen. Bulk chemistry by microprobe measurement on rock melts. Average from three analyses.

	RE 6	RE 7	RE 8	RE 12
CEC (meq/100g), total	79,0	73,0	47,0	86,0
Na^+ exchangeable cations	0,3	0,3	0,3	0,5
K^+ exchangeable cations	1,0	0,5	0,8	0,8
Ca^{++} exchangeable cations	44,0	60,0	50,0	70,0
Mg^{++} exchangeable cations	6,4	6,6	5,2	5,4
Total (meq/100g) of main interlayer cations	51,7	67,4	56,3	76,7

Tab. 2: Cation Exchange Capacity (CEC) and main interlayer cations of clay samples from test site Remigen.

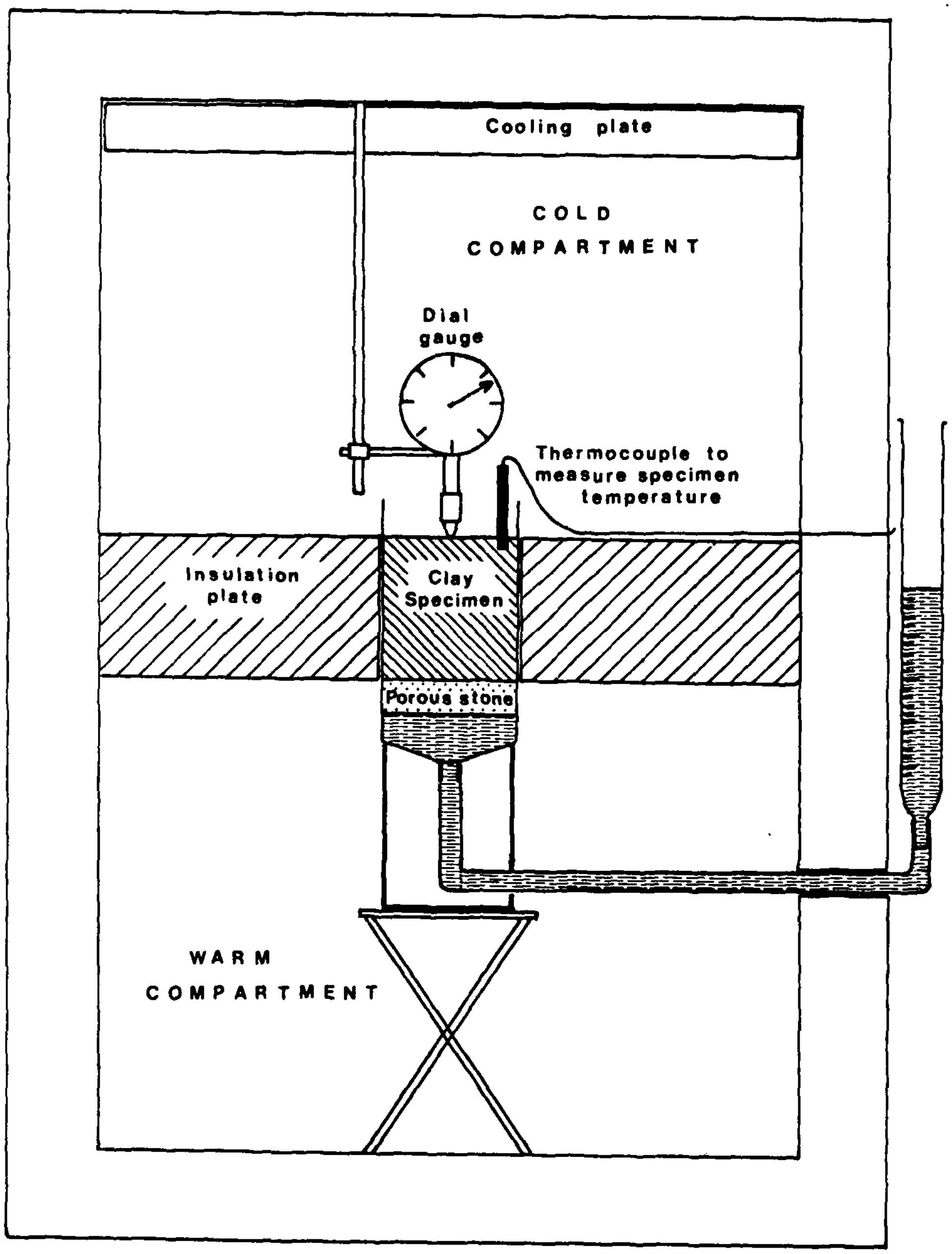

Fig. 1: System sketch of freezer for clay testing with cold compartment in the upper part and warm compartment in the lower part for steady water flow into the sample

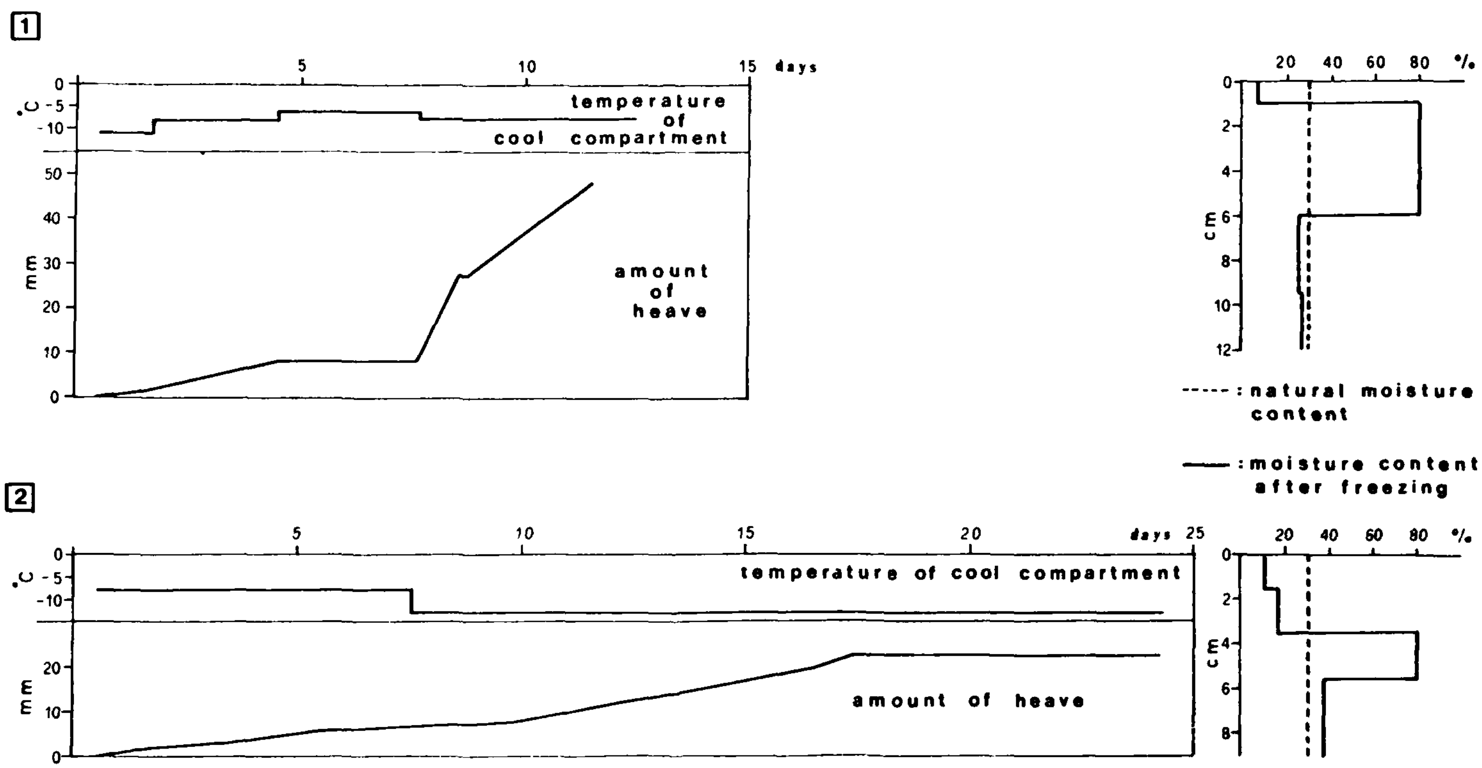

Fig. 2: Freezing test 1 and 2, amount of heave and temperature change of cool compartment

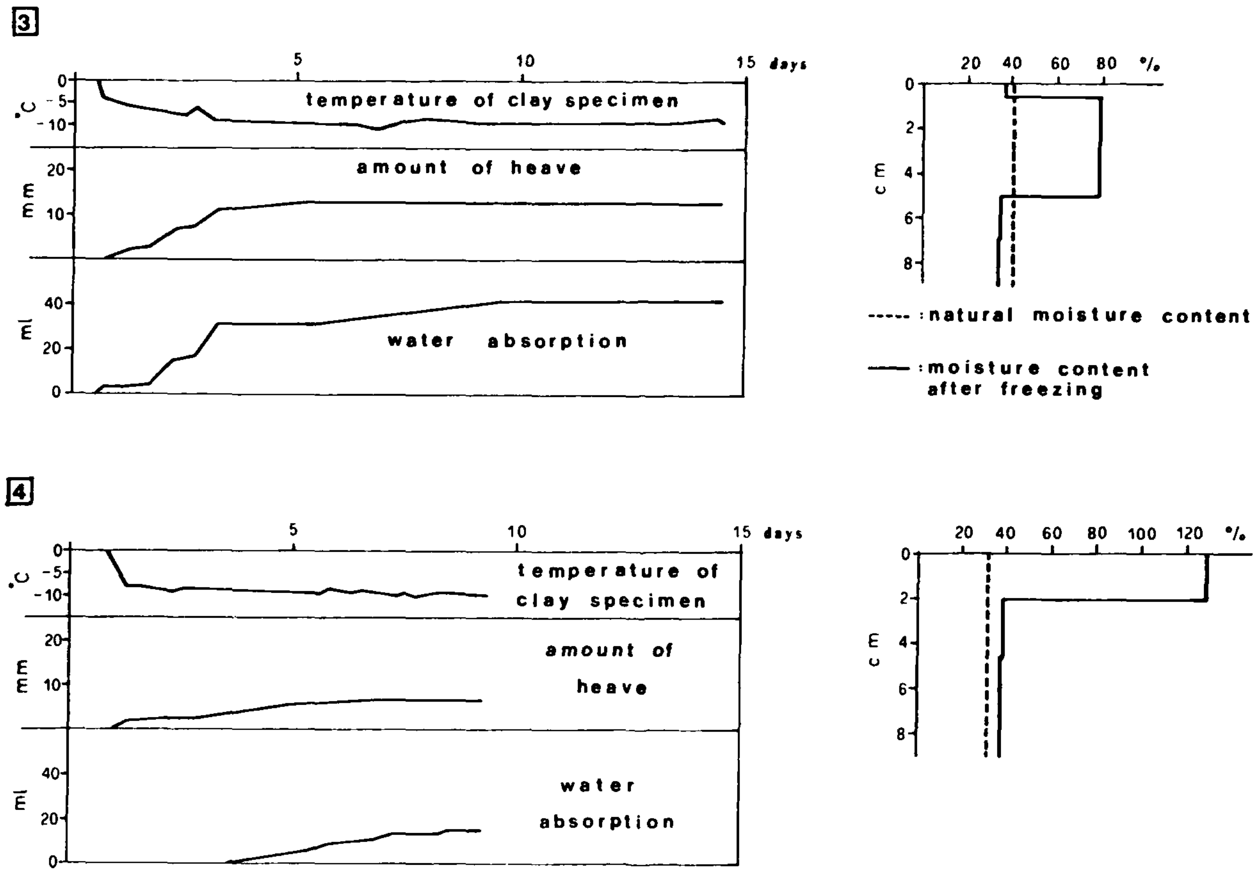

Fig. 3: Freezing test 3 and 4, amount of heave and water uptake, temperature change within the sample

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